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QUALITY CONTROL CONCEPT AND RECENT DEVELOPMENTS OF THE LIGHT CLIMATIC OBSERVATORY AT AROSA - OZONE MEASURING STATION OF THE SWISS METEOROLOGICAL INSTITUTE (LKO)

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ABSTRACT

Total ozone observations of two Dobson instruments (D15 and D101, C- and AD wavelength pair observations) and of two Brewer instruments (Br40 and Br72) are currently performed at the LKO at Arosa. A quality control concept is presented in order to make best use of the large number of quasi-simultaneous measurements.

The longest total ozone series of the world is mainly based on the measurements of the Dobson instrument D15 (wavelength pair C). Since the last years D15 has suffered from instrumental problems. The transformation of the longterm series to the measurements of D101(AD) is described.

1. INTRODUCTION

The Dobson spectrophotometer is the standard instrument of the global ozone monitoring network run under the auspices of WMO, which first indicated the global decrease of the ozone shield (OTP, 1990, Bojkov *et al.*, 1990). Recently, the results of the Dobson measurements have been mainly confirmed for the period after 1978 by the independently calibrated TOMS instrument (Total Ozone Mapping Spectrometer aboard satellite Nimbus 7) (Stolarski *et al.*, 1991 and 1992). Satellite measurements have the advantage of global coverage of the measurements. However, continuous measurements are only available since 1978 and they have to be confirmed by independent ground based measurements.

To get reliable total ozone observations suitable for trend analysis, high quality measurements have to be achieved. Since 1988 a program was started at LKO (Light Climatic Observatory - Ozone Measuring station of the Swiss Meteorological Institute) at Arosa, Switzerland, to partially automate the measurements and to improve the reliability of the ozone measurements by introducing redundance in the measurements (Hoegger *et al.*, 1991). Since 1991 total ozone observations have been performed by two Dobson and two Brewer spectrophotometers. We present here recent results of a quality control concept which was developed to make best use of the large number of quasi-simultaneous ozone measurements. We further describe the transformation of the measurements of D15 which suffers from instrumental problems to the measurements of D101 which is in line with the primary world Dobson instrument.

2. INSTRUMENTATION AND PERFORMED MEASUREMENTS

The recent developments of the LKO including the new installations is described in Hoegger *et al.*, 1992. Dobson spectrophotometers D15 and D101, which are located now inside a "spectrodome", were partially automated and the data transferred to a PC, where they are stored on a hard disk. D51 has been transformed to perform Umkehr measurements in a completely automated way. A window is opened at the beginning of the measurements and the instrument is driven in the proper position by a motor. The measurements of the balance point are automatically read out and also transferred to a PC. Tab. 1 shows the routinely performed ozone observations at Arosa.

Instrument	Observations	Degree of automation 1)
D15, D101	- direct sun, (AD and C) 2) - Umkehrmeasurements 3)	partial
D51	- Umkehrmeasuremtens 4)	complete
Br40	- direct sun - Umkehrmeasurements 4) - UV-B, one scan at noon	complete
Br72	- direct sun - UV-B, one scan every hour	complete

Table 1: Ozone observations routinely performed at the LKO.
1) : see Hoegger et al., 1992.;
2) : performed about every hour within the μ-range of 1.1 to 3.5, permitting weather conditions;
3): performed about three times per month;
4): performed every morning and evening.

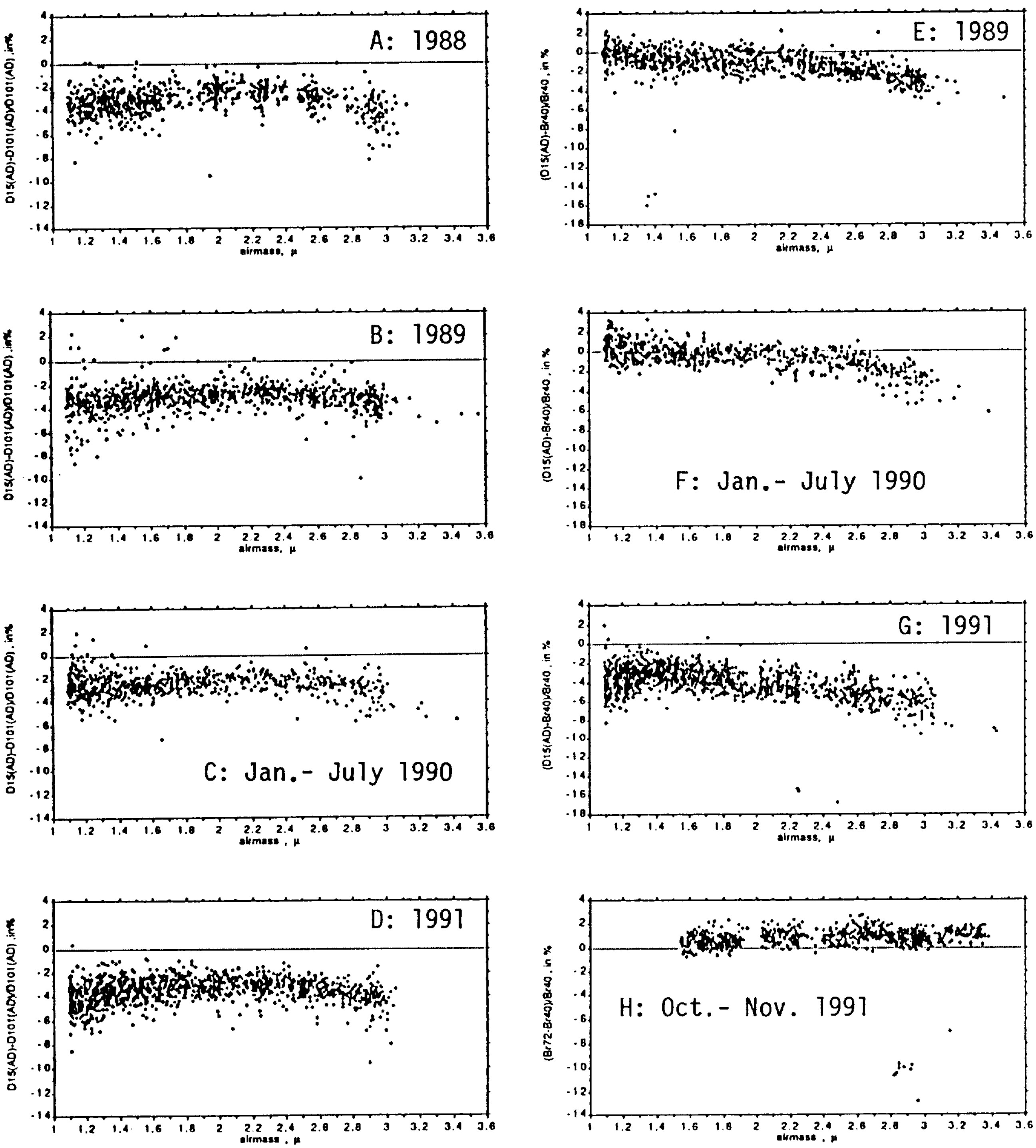

Fig. 1: Relative differences of quasi-simultaneous total ozone observations from LKO as function of μ for different years. The measurements are regarded as quasi-simultaneous if the difference between the measurements is less than 5 min. and less than 0.05 μ.

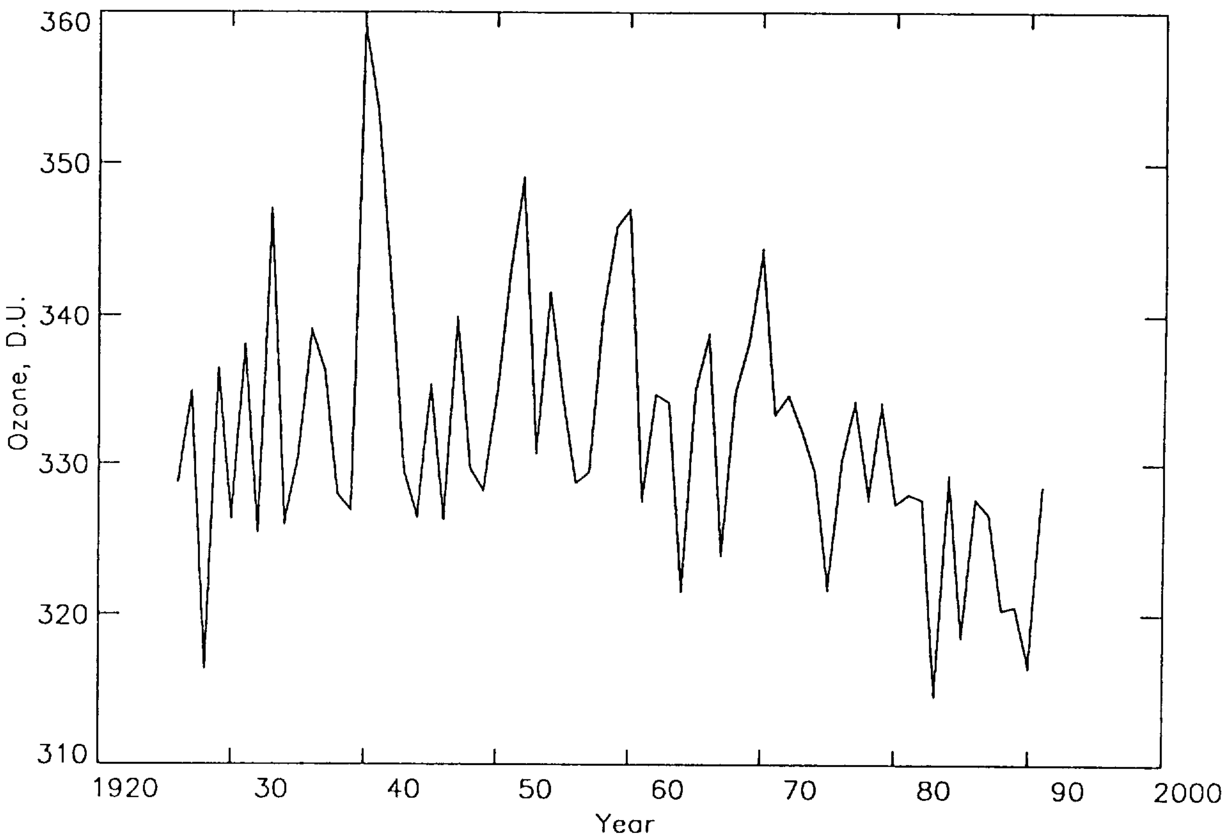

Fig. 2: Total ozone series of Arosa, adjusted to the Dobson world standard instrument (compare text).The results are given in the Bass-Paur scale.

D15 is calibrated by the procedure described by Dütsch, 1984, which is based on the statistical Langley plot method originally proposed by Dobson and Normand, 1962. The calibration of D101 was entirely changed in 1986, based on the intercomparison with the world standard instrument at Arosa (Komhyr *et al.*, 1989). The calibration of D15 was left unchanged to avoid a break in the world longest series of total ozone observations. However, since 1986 measurements from D15 and D101 are no longer entirely redundant. The intercomparison 1990 at Arosa indicated, that D101 kept calibration well since 1986 and only small changes in the R/N table had to be applied. In order to have an homogeneous data set for the data intercomparison we have recalculated the single measurements of D101 since July 1986 using the slightly corrected R/N-table from the intercomparison of 1990. A Brewer instrument Br40 was purchased in Sept. 1988, Br72 in June 1991. The two Brewer instruments introduce two completely redundant series of total ozone observations at the LKO.

3. RESULTS FROM DATA QUALITY CONTROL

The data quality control concept of the LKO was developed to make best use of the large number of quasi-simultaneous measurements. It is based on the following comparisons:

- All total ozone observations from one day are plotted as function of the day time using different symbols for the different types of measurements. Outliers of single measurements therefore can be easely detected.

- Differences and relative differences of pairs of quasi-simultaneous measurements of two instruments are depicted as a function of the air mass μ (Fig.1). Total ozone observations from Dobson instruments calibrated against the world primary standard instrument and from Brewer instruments calibrated against the Canadian Brewer triade seem to have a systematically different behavior in the μ-dependence, which was reported before (Kerr *et al.*, 1988, Hoegger *et al.*, 1992). When employed on an annual or semiannual basis temporal changes in the relative calibration from one to another instrument can be detected using plots of the type of Fig.1. This provides an additional test on the longterm stability of calibration of the instruments besides the routinely performed lamp tests.

The results of the comparison of the quasi simultaneous measurements from the different series are shown in Fig.1. The μ-difference between D15(AD) and D101(AD) was similar from 1988 to July 1990 (Fig. 1a-c). A break occurred in the middle of 1990 (comp. 1a-c with 1d), which is also evident comparing D15(AD) with Br40 (compare Fig. 1g with 1e and 1f).

The measurements from the two Brewer instruments - instrument Br72 ran without problems since Oct 1991 - usually agree well with each other (see Fig.1h). The relative difference is less than 1%, except for one day (Dec. 11), when the measurements of Br72 were much to low. The reason of this instrumental failure of Br72 has not been discovered yet.

4. TRANSFORMATION OF THE D15(C) TO THE D101(AD) SERIES

Fig. 1 indicates, that a break occurred in the series of D15 during 1990 and the results of the intercomparison showed that D15 is no longer in good instrumental condition. We therefore decided to transform the whole D15(C) series into the D101(AD) series.

In the first step the transformation of the D15(AD) into the D101(AD) measurements was calculated using the data from 1988 to 1991. This difference was assumed to consist of the sum of a constant and a seasonal term. The seasonal deviation was modelled by a polynomial of order 6, for which 4 parameters had to be estimated and 3 are fixed by the boundary conditions. The nonseasonal term was modelled by a two step function taking into account the break in the data of instrument D15 which occurred in July 1990.

For the time before 1956 only measurements of single wavelength pairs were made. All these old data have been homogenized to the measurements of the wavelength pair C (Birrer, 1975). However, single wavelength pair measurements are sensitive to Mie scattering caused by atmospheric aerosols. The difference between AD- and C-wavelength pair measurements can be as much as 30 DU during hazy summer days. The differences between the monthly mean values from AD- and C wavelength pair measurements show a typical seasonal variation. From the period 1963 to 1988 the absolute difference between the C- and AD-monthly mean values were calculated using the same approach as described above. These correction factors and the transformation of the D15(AD) to the D101(AD) measurements were applied to transform the D15(C) series to a "quasi D101(AD) series, which is shown in Fig.2.

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REFERENCES

Birrer, W. (1975): Homogenisierung und Diskussion der Totalozon-Messreihe von Arosa, 1926-1971, *LAPETH*, **11**.

Bojkov, R., Bishop, L., Hill, W.J., Reinsel, G.C. and Tiao, G.C. (1990): A statistical trend analysis of revised Dobson total ozone data over the northern hemisphere, *J. Geophys. Res.*, **95**, 9785-9807.

Dobson, G.M.B. and Normand, C.W.B. (1962): Determination of constants used in the calculation of the amount of ozone from spectrophotometer measurements and an analysis of the accuracy of the results, *Ann. Internat. Geophys. Year*, **16**, 161-191.

Dütsch, H.U. (1984): An update of the Arosa ozone series to the present using a statistical instrument calibration, *Quart. J. R. Met. Soc.*, **110**, 1079-1096.

Hoegger, B., Levrat, G., Schill, H., Staehelin, J. and Ribordy, P. (1992): Recent developments of the Light Climatic Observatory - Ozone measuring station of the Swiss Meteorological Institute (LKO) at Arosa, *J. Atmos. Terrest. Phys*, **54**, 497-505.

Kerr, J.B., Asbridge, A., and Evans, W.F.J. (1988): Intercomparison of total ozone measured by the Brewer and Dobson spectrophotometers at Toronto, *J. Geophys. Res.*, **93**, 11 129- 11 140.

Komhyr, W.D., Grass, R.D., Evans, R.D., and Leonard, R.K. (1989): Results of the international Dobson spectrophotometer and Brewer spectrophotometer calibrations, Arosa, Switzerland, 1986, in *Ozone in the atmosphere*, R.E. Bojkov and P. Fabian, Eds., Deepak Publ., p. 776.

OTP (1990): Report of the International Ozone Trends Pannel:1988, *World Meteorological Organization, Global Ozone Research and Monitoring Project*, Report No. 18, World Meteorological Organization, Geneva, Switzerland.

Stolarski, R.S., Bloomfield, P., McPeters, R.D. and Herman, J.R. (1991): Total ozone trends deduced from Nimbus 7 TOMS data, *Geophys. Res Lett.*, **18**, 1015-1018.

Stolarski, R.S., Bojkov, R., Bishop, L., Zerefos, C., Staehelin J. and Zawodny, J. (1992): Measured trends in stratospheric ozone, *Science*, **256**, 342-349.